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(54) **A powder-metallurgy method for producing tubular product.**

(57) A powder-metallurgy method for producing tubular product having at least one surface (16), preferably an internal surface, thereof clad with an alloy different from and preferably more resistant to destructive media than the material from which the remainder of the tubing is constructed. An assembly (10) is constructed of a metal tubing (12) having an internal surface (16) to be clad and a tubular insert (14) is mounted generally axially within the tubing (12) in spaced-apart relation to the internal surface (16) thereof, which provides a generally annular cavity (18) between the internal surface (16) of the tubing (12) and the tubular insert (14). This cavity (18) is filled with metal particles (26) of a composition to be clad on the tubing internal surface (16). The cavity (18) is sealed and the assembly (10) is heated to an elevated temperature at which it is forged to compact the metal particles (26) introduced to the cavity (18) to substantially full density and metallurgically bond

the particles (26) to the internal surface (16) of the tubing (12) to provide a desired destructive-media resistant cladding. The forging operation includes passing the assembly (10) along a feed path having an axis through a forging box having a plurality of hammers (32) evenly spaced around the assembly (10). The hammers (32) extend and retract radially with respect to the feed-path axis to impart a radial forging action to the assembly (10) as the assembly (10) passes through the forging box.

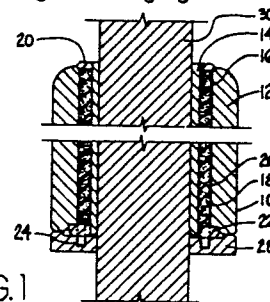


FIG. 1

EP 0 220 800 A1

A POWDER-METALLURGY METHOD FOR PRODUCING TUBULAR PRODUCT

The present invention relates to a powder-metallurgy method for producing tubular product.

In applications, such as oil well drilling, the petrochemical industry and geothermal installations, there is a need for tubing that is highly resistant to the destructive media of substances flowing through the tubing. This destructive media, depending upon the particular application, may include corrosive media, abrasive media, high-temperature media and combinations thereof. For these applications it is known to use monolithic tubing of alloys that are highly resistant to destructive media, which would include nickel-base alloys, such as INCO 625. With monolithic tubing constructed from conventional alloys of this type, the cost of the finished tubing is typically of the order of U.S. \$50 per foot (U.S. \$50 pa 0.3048m), and the cost may be much higher for large -diameter tubing. This adds considerably to the overall cost of installations with which tubing of this type is employed.

It is accordingly a primary object of the present invention to provide a method for producing tubular product having at least one clad surface, and preferably an interior surface, of a conventional alloy which is preferably resistant to destructive media with the remainder of the tubing being constructed from a different material that is preferably less resistant to destructive media, and thus a lower cost material; in this manner, tubing suitable for use in applications embodying destructive media may be produced at a much lower cost than using monolithic tubing of the required destructive-media resistant alloy.

A more specific object of the invention is to provide a method for producing internally clad tubing suitable for use in destructive-media applications wherein internal cladding is provided by a powder-metallurgy practice wherein metal particles of the desired destructive-media resistant alloy are used to clad the internal surface of tubing by a forging operation to compact the metal particles to substantially full density and metallurgically bond them to the internal surface of the tubing.

In accordance with these objects, and broadly in accordance with the invention, the method thereof for producing tubular product having on at least one surface thereof, and preferably an internal surface, cladding of an alloy different from and preferably more resistant to destructive-media than the surface to be clad comprises constructing an assembly including a metal tubing having surface to be clad, a tubular insert mounted generally axially with said tubing in spaced-apart relation to the said surface thereof to provide a generally annular cavity

between said surface and said tubular insert. This cavity is filled with metal particles of a composition different from and preferably more resistant to the destructive-media than the surface to be clad or the remainder of the tubing. The assembly is heated to an elevated temperature and forged to compact the metal particles to substantially full density and metallurgically bond the particles to the said surface, whereby cladding is produced on the surface of the tubing and preferably on an internal surface. During the forging operation, the metal tubing may be elongated. The assembly may include for sealing the powder-filled cavity, two annular rings each connected in sealing engagement between adjacent ends of the tubing and the tubular insert at opposite ends of the assembly. The cavity may be filled with metal particles through at least one stem that extends into the annular cavity. The stem is adapted for sealing prior to forging. The stem may extend through one of the annular rings and, after filling the annular cavity with metal particles and prior to forging, the cavity is sealed by crimping the stem and connecting an annular cap in sealing engagement between adjacent ends of the tubing and the insert and over the crimped stem.

Further in accordance with the invention, the assembly is forged by the use of a mandrel extending within the assembly which is moved along a feed path having an axis through a forging box. The forging box has a plurality of hammers evenly spaced around the assembly. The hammers are adapted to simultaneously extend and retract radially relative to the axis to impart a radial forging action to the assembly as the assembly passes through the forging box. This forging action is of a magnitude and duration to compact the particles to substantially full density and metallurgically bond the particles to the internal surface of the tubing.

The invention will be more particularly described with reference to the accompanying drawings, in which:-

Figure 1 is a sectional view of one embodiment of an assembly suitable for use in the method of the invention for producing a metal tubular product having an internal surface clad with an alloy of a metallurgical composition different from the surface being clad or the remainder of the tubing, and

Figure 2 is an end view of the assembly of Figure 1 showing schematically forging hammers and a mandrel in accordance with the method of the invention as applied to the assembly in the practice of the method of the invention.

With reference to the drawings, and for the present to Figure 1, there is shown an assembly

suitable for use in the practice of the method of the invention. The assembly, generally designated as 10, includes a tubing 12, which may be of an alloy that is less resistant to destructive media than required for a particular application. Typically, the tubing may be alloy steel or plain carbon steel. The only requirement with regard to the material from which the tubing is constructed is that it be forgeable. Positioned generally axially within said tubing 12 and having a diameter less than the internal diameter of the tubing 12 is a tubular insert 14. The tubular insert 14 may be constructed from the same material as the tubing 12, but this is not a requirement. The insert 14, as shown in Figure 1, is in spaced-apart relation from internal surface 16 of the tubing 12. The area between insert 14 and internal surface 16 of tubing 12 constitutes an annular cavity 18. An annular metal ring 20 is connected in sealing engagement, as by welding (not shown), between adjacent ends of the tubing 12 and insert 14 at one end of the assembly 10. The annular ring 20 in this manner seals the end of the cavity 18 at which it is connected. At the opposite end of the cavity 18 from the ring 20 there is provided a second annular ring 22 that is similarly connected in sealing engagement between adjacent ends of the tubing and the tubular insert. The annular rings 20 and 22 are constructed of metal which may be the same as that of insert 14. Two identical metal stems 24 extend into the cavity 18. Metal particles, designated as 26, are introduced to the cavity 18 through stems 24. The metal particles are of a composition different from the tubing surface to be clad, and preferably of a material that is more resistant to destructive media than the material of the surface to be clad. Although two stems are shown for this purpose in Figure 1, any suitable number may be employed. The stems 24 extend through annular ring 22. After filling the annular cavity 18 with metal particles 26 introduced through the stems 24, the stems are crimped, which is the configuration shown in Figure 1 and an annular cap 28 is connected in sealing engagement between adjacent ends of the tubing and insert and over the crimped stems. The cap is connected as by welding (not shown) to tubing 12 and ring 22. In this manner, the end of the cavity 18 opposite that of ring 20 is likewise sealed after filling of the cavity with the metal particles 26.

The assembly 10 after filling of the cavity 18 thereof with metal particles and sealed as shown in the drawing, is heated to a temperature for forging which temperature is typically within the range of 1000 to 2200°F (538 to 1204°C).

The assembly is forged by placing a mandrel 30 longitudinally within insert 14, as shown in Figures 1 and 2. Preferably, the forging box has four hammers 32 which are evenly spaced around the

assembly, as shown in Figure 2. The hammers strike simultaneously at a rate of 175 to 2000 times per minute. In this manner, the circumference of the assembly as it moves longitudinally through the forging box is subjected to an all-sided, sequential forging operation with the mandrel supporting the assembly and over which the tubing is elongated. The forging operation provides for uniform, rapid forging along the entire circumference of the assembly so that full density and metallurgical bonding of the particles to the tubing interior is achieved. The apparatus suitable for use with the practice of the invention may be that described in Kralawetz U.S. Patent 3,165,012. The forging machine of this patent has four hammers that are radially directed toward the axis of the workpiece, which workpiece is moved longitudinally through a forging box embodying the hammers which are driven by driving shafts eccentrically mounted to cause the hammers to perform a reciprocating, sequential forging action. During forging, and incident to this compacting and bonding operation, the tubing may be elongated about two to ten times its original length.

After forging the annular rings 20 and 22 and cap 28 may be removed to provide a tubing having the desired interior clad surface. Likewise, insert 14 may be removed by a machining operation which may be chemical or mechanical or by a combination of chemical and mechanical action. There may be applications wherein the insert may remain on the compacted tubing. The insert is bonded to the compacted particles 26 during the forging operation.

The metal particles 26 may be produced by any of the well known practices for manufacturing powder particles suitable for powder-metallurgy applications. One preferred practice, however, is to gas atomize a molten metal stream to produce discrete prealloyed particles which are rapidly cooled within a protective atmosphere and collected for use.

It is to be understood that the term "metal" as used in the specification and claims includes alloys as well as carbides, such as tungsten carbides and the like and the terms "metal" and "alloy" are used interchangeably. The metal particles in applications requiring resistance to a highly abrasive media may be particles of carbides, such as tungsten carbides, which are highly resistant to abrasion.

Although the invention has been described and claimed with respect to cladding "tubing", it is to be understood that various cylindrical products could be made by the practice of the invention which might be used in other than tubing applications.

Prior to forging and incident to the heating operation of the assembly, the cavity 18 of the

assembly may be connected through stems 24 to a pump which may be used to evacuate the chamber interior to remove deleterious gaseous-reaction products prior to sealing the cavity, which operation is conventionally termed "out-gassing."

Claims

1. A powder-metallurgy method for producing tubular product having on a metal surface thereof a cladding of an alloy of a metallurgical composition different from said surface characterised in that, said method comprises constructing an assembly - (10) including a metal tubing (12) having at least one surface (16) to be clad, a tubular insert (14) mounted generally axially with said tubing (12) in spaced-apart relation to said surface (16) to provide a generally annular cavity (18) between said surface - (16) and said tubular insert (14), filling said cavity - (18) with metal particles (26) of a metallurgical composition different from said surface (16), sealing said powder-filled cavity (18), heating said assembly (10) to an elevated temperature and forging said assembly (10) to compact said metal particles (26) to substantially full density and metallurgically bond said particles (26) to said surface (16), said forging including passing said assembly (10) along a feed path having an axis through a forging box having a plurality of hammers (32) evenly spaced around said assembly (10) and adapted to extend and retract radially with respect to said axis to impart a radial forging action to said assembly (10) as said assembly passes through said forging box.

2. A method according to claim 1, wherein said tubing is elongated during said forging over a mandrel (30).

3. A method according to claim 1 or 2, wherein said assembly (10) includes for sealing said powder-filled cavity (18) two annular rings (20,22), each connected in sealing engagement between adjacent ends of said tubing (12) and tubular insert (14) at opposite ends of said assembly (10).

4. A method according to claim 1, 2 or 3 wherein said assembly (10) includes at least one stem (24) extending into said annular cavity (18) through which said metal particles (26) are introduced during filling of said cavity therewith, said stem (24) being adapted for sealing prior to forging.

5. A method according to claims 3 and 4, wherein said stem (24) extends through one of said annular rings (22) and after filling said annular cavity (18) with said metal particles (26) and prior to

forging said cavity (18) is sealed by crimping said stem (24) and connecting an annular cap (28) in sealing engagement between adjacent ends of said tubing (12) and said insert (14) and over said crimped stem (24).

6. A method according to any one of the preceding claims, wherein said surface (16) of said metal tubing (12) is an internal surface and said tubular insert (14) is mounted axially within said tubing (12).

7. A powder-metallurgy method for producing tubular product having on an internal surface thereof an internal cladding of an alloy more resistant to destructive media than said internal surface, characterised in that said method comprises constructing an assembly (10) including a metal tubing (12) having an internal surface (16), a tubular insert (14) mounted generally axially within said tubing (12) in spaced-apart relation to said internal surface (16) thereof to provide a generally annular cavity (18) between said internal surface (16) and said tubular insert (14), filling said cavity (18) with metal particles (26) of a composition more resistant to destructive media than said internal tubing surface (16) through at least one stem (24) extending into said annular cavity (18), sealing said cavity (18) by connecting in sealing engagement two annular rings (20,22) between adjacent ends of said tubing (12) and said insert (14) at opposite ends of said assembly (10), crimping said stem (24) and connecting an annular cap (28) in sealing engagement between adjacent ends of said tubing (12) and said insert (14) and over said crimped stem (24), heating said assembly (10) to elevated temperature and forging said assembly (10) to compact said metal particles (26) to substantially full density, metallurgically bond said particles (26) to said internal surface (16) and elongate said tubing (12), said forging including passing said assembly (10) along a feed path having an axis through a forging box having a plurality of hammers (32) evenly spaced around said assembly (10) and adapted to extend and retract radially with respect to said axis to impart a radial forging action to said assembly (10) as said assembly passes through said forging box.

8. A method according to claim 5 or 7, wherein after said forging said annular rings (20,22) and said annular cap (28) are removed.

9. A method according to any one of the preceding claims, wherein after said forging said tubular insert (14) is removed.

10. A method according to claim 9, wherein said tubular insert (14) is removed by chemical and/or mechanical means.

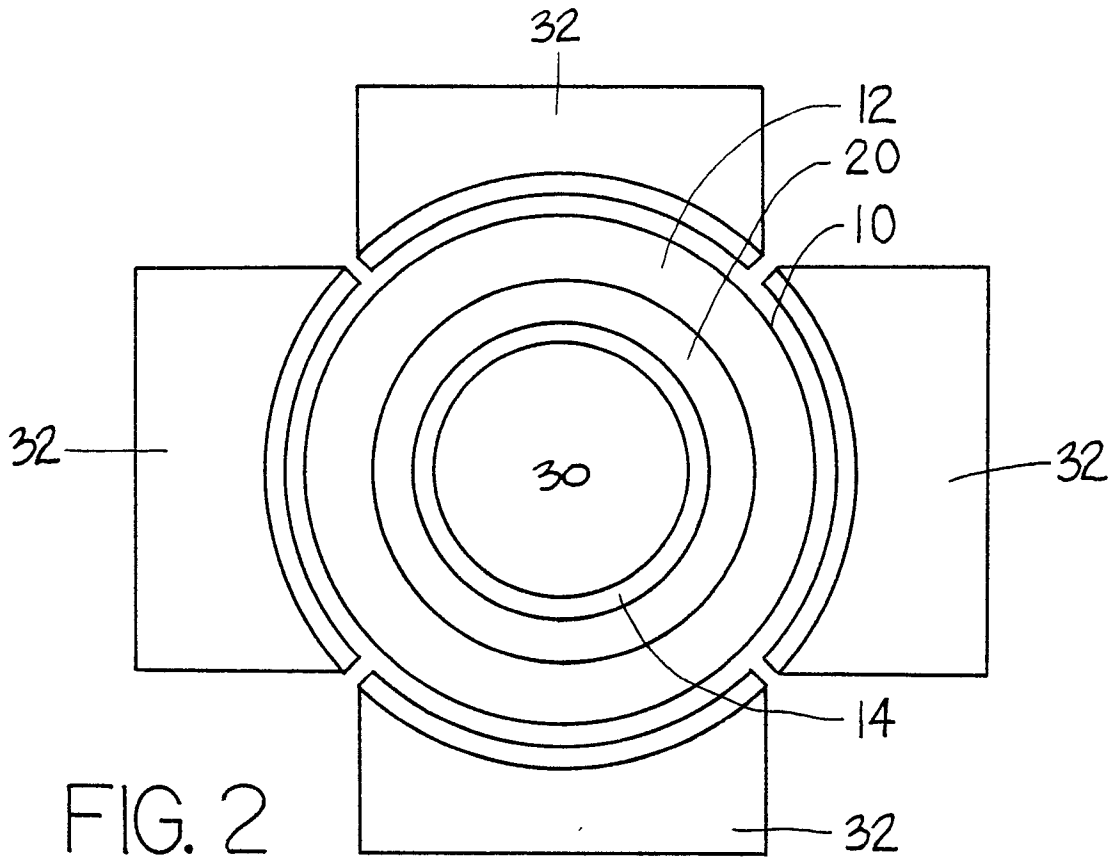


FIG. 2

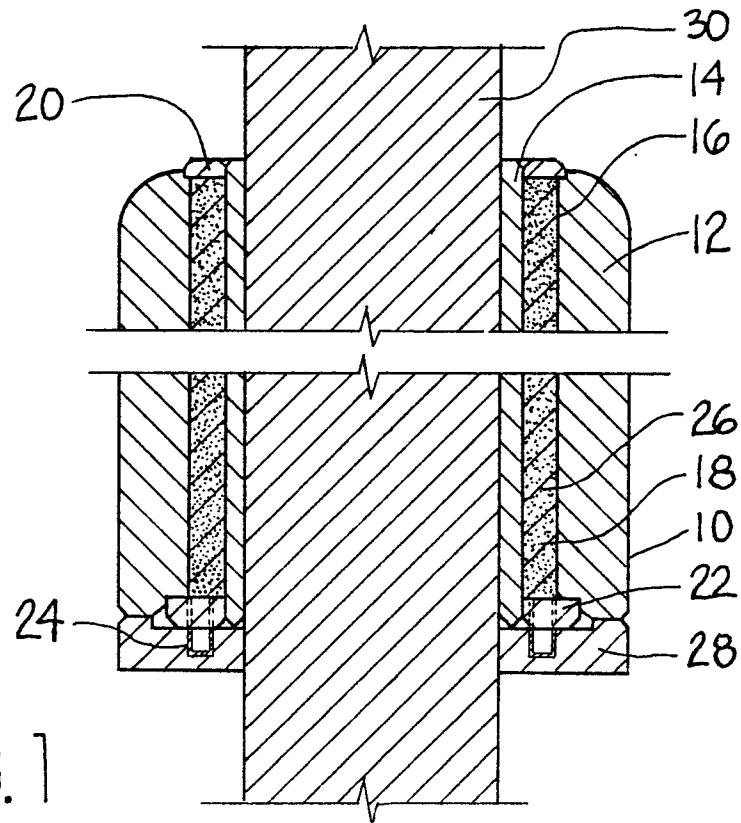


FIG. 1



EP 86 30 6066

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
P,X	EP-A-0 162 549 (CRUCIBLE) * Claim 1 *	1,7	B 22 F 7/08 B 22 F 3/16
Y	--- US-A-3 834 004 (M.D. AYERS) * Claims 1,4,11,12 *	1,7-10	
Y	--- EP-A-0 114 591 (VEW) * Claims 1,3,4; page 7, lines 6-12 *	1-10	
Y	--- DE-A-2 556 061 (H. SEILSTORFER) * Claims 1,3; page 9, line 22 - page 11, line 18 *	1-10	
Y	--- FR-A-2 372 671 (ASEA) * Claim 1 *	5,7	TECHNICAL FIELDS SEARCHED (Int. Cl.4)
A	--- WO-A-8 000 803 (GRÄNGES NYBY) * Page 14, line 17 - page 17, line 12 *	5,7	B 22 F

The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 28-01-1987	Examiner SCHRUERS H. J.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			